Mind, Brain and Performance

Report of a one-day Symposium held at Sadler's Wells Theatre, London, on 7 November 2006, organised by the Calouste Gulbenkian Foundation with University College London and Arts Council England.

The Symposium invited cognitive neuroscientists and professional dance and performance artists to explore the implications of new scientific research for the performing arts (specifically dance) in order to encourage mutual learning, research and creative opportunities.

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Background

***Siân Ede**, Arts Director, UK Branch Calouste Gulbenkian Foundation*

The UK Branch of the Gulbenkian Foundation has been bringing artists and scientists together for almost 10 years. While we are primarily interested in supporting artists to develop their thinking and practice in order to make new work, we have also sought to encourage scientists to understand the unusual and imaginative response to the world that artists take, with a view to giving greater credibility to other ways of thinking intelligently (visually, dramatically, kinetically), beyond the cerebral, rational and logical. And we have been interested to point out how cultural values play a part in informing science, if not quite as much they do in informing the arts.

Gulbenkian occasionally holds informal 'salons', bringing together small numbers of artists and scientists to discuss particular ideas, with each side taking examples from their current work. The idea for this Symposium came from Patrick Haggard who, as he explains below, had stumbled somewhat unexpectedly into research into the changing 'line' in classical ballet. At an earlier Gulbenkian salon he described his research to arts practitioners, all of whom were beguiled, though not always convinced. 'Why should you want to?' performance artist Bobby Baker asked when presented with Patrick's desire to find general principles underlying audience responses to particular dance movements. 'My shows are different every time I perform them, and from minute to minute!' On the other hand, theatre director Neil Bartlett seemed to experience a Damascene moment when introduced to the function of mirror neurons. Now he understood, he said, why he was sometimes inexplicably moved to tears when watching a 'dying fall' in ballet. He felt he was trying to move inwardly with the dancer on stage, even while he was frustrated by the limitations of his own untrained body.

Patrick and I decided to open up the discussion to a forum of selected experts and to expand the number of participants to a slightly larger yet still manageable group. The then Dance Director at Arts Council England, Jeanette Siddall, was brought in to help with the planning and argued for including dance promoters as well as practitioners. A programme was agreed. Sadler's Wells proved to be a fine location for the Symposium, a place of serious dance investigation and performance, with a light, bright meeting room and a whiff of glamour in the foyers, refreshingly different for scientists used to more utilitarian accommodation.

This Symposium may be the first of many. It is likely that Gulbenkian may reconvene the group and take the discussion further. But it is to be hoped that individual participants – the neuroscientists, the dance producers and promoters, choreographers and performers, academics and trainers – will take from this forum ideas they particularly wish to pursue and thereby cascade encounters and debates into new and different settings. It is also to be

hoped that new relationships will have been forged and that new collaborations might one day ensue. Neuroscience is often hard to understand. Contemporary dance is not simple entertainment. We should not be afraid to acknowledge the challenges that both disciplines provide, encouraging students and audiences – as one would a novel-reader, a concert-goer or a wine-drinker – that the more we engage with understanding the history, language and form, the greater the understanding and pleasure that lie in store.

The following summaries have been organised and edited for the reader and do not provide a verbatim record of the Symposium proceedings. Throughout the day we took a topic and paired a scientist and a dance specialist to address it from their different perspectives. With hindsight, some of these pairings work better in a new configuration. We have therefore made some alterations to the running order of the talks. In Session 1 we have paired Vittorio Gallese's discourse on mirror neurons with an interview with Wayne McGregor, who was originally to appear in this session but had unavoidable rehearsal demands at the last moment. We have moved the contributions by the Laban team, Emma Redding, Shantel Ehrenberg and John Gruzelier, which thankfully took his place, to a separate section. In Session 3 we have paired Jonathan Cole's talk on proprioception with Chris Bannerman's on intuition and explanation, as these both address the question of observing the body from within and without. We have consequently placed Ruth Webb's account of the role of dance in a specific cultural setting with Patrick Haggard's talk, which quantifies the artistic evolution of body position in recent classical dance, in Session 4.

It has proved impossible to capture the audience discussion which often flowed naturally, covering a lot of ground and sometimes introducing ideas and hypotheses as interesting as those of the speakers. For this we apologise but can be sure that those participants will have taken new ideas back to their home territories and, we hope, be thinking of disseminating them further.

Thanks must go to rapporteur Annabel Huxley who made the copious notes which inform this text.

Introduction and Context

The introductory session of the Symposium provided brief overviews of developments and the current state of play in neuroscience and in dance, beginning to identify some of the reasons why the two disciplines might be of mutual interest to each other.

The Scientist's View

***Patrick Haggard**, Professor of Cognitive Neuroscience, University College London*

Dance is almost universal in human culture. People dance for many reasons, and dance comes in many forms. However, dance as a performing art depends on two indispensable elements: a dancer moving their body and an audience that watches these movements. Although dance performances may involve many other components, such as music, narrative or costume, none of these seems essential in the way that moving and watching are.

This analysis has direct implications for the brain processes that underlie dance. In dance performance, the motor system of one person's brain produces movement. This in turn forms the input to the visual system of another person's brain. Modern neuroscience has achieved a fairly good understanding of the motor and visual systems, but just describing the anatomy of these brain areas does not explain why dance performances can have such profound and intense psychological effects on both dancer and audience. The motor and visual systems must be interacting with a much wider range of brain circuits to produce the amazing experience that dance can provide. So how can dance work, as an art form, through the human brain?

My personal interest in the links between dance and the human brain arose quite accidentally. I was asked to write some research briefs on sensory and motor brain systems for a TV series about dance. I became interested: professionally, I began to do behavioural and neuro-imaging experiments with dancers, and, personally, I began to enjoy watching dance for the first time.

There are several reasons why a scientific study of dance is worthwhile. First, the field is wide open for inquiry: there has been almost no previous work on what brain processes make dance functional, pleasurable and appealing. Second, the field is scientifically tractable: the basic brain regions can be identified, dance performance itself can be quantified, and the codified quality of many dance movements makes experiments easy to construct and replicate. Third, there's a strong level of interest and support from the dance community.

The aim of this Symposium was to identify possible ways in which dance and brain sciences could interact, and how they could mutually benefit from this interaction. In a sense, particular brain processes form the raw materials that choreographers and dancers have to work with when they want to express themselves through their work and to communicate with their audiences. Brain scientists can also learn from studying dance. For myself, an

enduring fascination is how quite simple, low-level perceptions and actions can produce vivid conscious experience, a sense of engagement and even wonder. I'm intrigued by the possibility of how dance can do that.

To highlight particularly significant research: in the last few years, neuroscientists have discovered two specific brain circuits that I feel may be very important for the way dance works. First, neuro-imaging studies have found a specific region of the visual system at the back of the brain which 'lights up' when looking at human bodies. This area appears to be tuned to recognise configurations of the body in the same way that other brain regions are known to recognise faces. Dance could be a particularly powerful stimulus for this dedicated brain circuit. Second, studies in animals and humans have identified an important brain circuit concerned with representing the actions of other individuals: the so-called 'mirror system'. The original studies in animals found that individual nerve cells in parietal and premotor areas were activated both when actually *making* a particular kind of action (such as grasping with the hand) and when *watching* another animal perform exactly the same action. Neuro-imaging studies in humans showed activity in the same areas in the same circumstances. Mirror neurons link actions that we see others perform to the motor programmes that we would use to perform the same actions ourselves. Clearly, this is a brain circuit with enormous potential value – for simulation, empathy, communication and social understanding. These key elements might depend on exactly the simple links between individuals' visual and motor systems that are involved in dance. By watching the movements of the dancer, we can simulate and internalise the feelings and motivations that make them move as they do.

I'd like to end with a word about methodology. Science tends to look for explanations that are both general, applying to a range of different phenomena, and analytic, reducing complex phenomena to simpler ones. Artists, of course, work quite differently. But these different ways of working do not undermine or invalidate each other. In fact, they can complement each other, particularly when both approaches can focus on a common problem. Some of the research discussed in this Symposium amounted to a scientific attempt to reduce dance to its most essential elements. But to reduce does not mean to destroy. The scientific attempt to understand dance or other arts is not dismissive; rather, it comes from a respect for art, and for the power of its creative methods.

The Dance Specialist's View

***Jeanette Siddall**, Consultant, former Director of Dance, Arts Council England*

As artistic practice, by which I mean the making and understanding of meaning through movement, dance is far more diverse and wide-ranging today than it has ever been. It embraces many different genres, from classical ballet to South Asian dance, from dance of the African diaspora to contemporary Western performance. It may be narrative, lyrical or abstract, and it may be experienced in theatres, public spaces, opera and musicals, and on film and television.

Dance has an ancient history, of course, but as little as hundred years ago in Britain dance as formal performance was mainly confined to turns in the music hall or theatre. There was a radical change when, in 1909, the Russian impresario Sergei Diaghilev brought a new bold performance aesthetic to European dance, opera and the visual arts. For the next 50 years Russian ballet had an enormous impact in the West, its increasing popularity reaching beyond an elite audience (during the Second World War it was toured to the troops and factory workers). That dance came to be regarded as high art, to be promoted to larger audiences, may have been partly due to John Maynard Keynes, the first chairman of the new Arts Council, created in 1946, who was a passionate devotee of ballet.

During the late 1950s and 60s a new kind of contemporary dance exploded on to the scene in New York, pioneered by such revolutionary choreographers as Martha Graham and Merce Cunningham. Their abstract works allowed a greater freedom of movement and linked in with a similar aesthetic, drawn from modernism and minimalism, in music and the visual arts. Such creations inspired choreographers to break down boundaries and rules and to experiment with form. From this impetus the contemporary dance scene has become varied and vibrant and nowadays often evades generic definition, drawing on a host of dance cultures and traditions. In the UK there are about 90 securely established dance organisations besides a ferment of small-scale projects by younger practitioners. Production values are often very high, bringing together new music composition, visual settings and lighting design and even the spoken word. In the arts, the dance world was the first to experiment with digital technology, which is often incorporated into performances to sometimes startling illusory effect.

Dance attracts a strong minority audience but is still not properly understood among the wider public who may have lingering concerns about its physical expression being too exotic, flagrant or effeminate. In a society where rational and linguistic thinking predominate, physical expression, particularly the movements of dance, whether brazen or nuanced, are viewed with suspicion or at least puzzlement. The abstract nature of much contemporary dance is also mystifying for many. It defies literal meaning yet it is undoubtedly emotionally laden.

Dance remains a part of PE in the school curriculum, where it may be seen as merely a form of exercise, and has had to gain academic respect in higher education through examination and theoretical research. Lately, however, as with other practising art forms, new ways of assessing dance aesthetically, as well as intellectually, socially and historically, are being accepted by the Higher Education Councils. The relationship between dance and science has developed since the 1980s, initially linked to sport science, with a focus on the physicality and psychology of optimum performance. Investigations into the neuroscience of dance are still relatively new but are potentially hugely important. Besides invigorating the making of dance, a better understanding of the brain can help in promoting understanding about the exchange between artist and audience. Dance still inspires, challenges, and takes me to new and extraordinary places in ways that I don't really understand. I am very aware that I can sit next to someone watching the same performance in the same theatre and yet we will have totally different experiences. I know I am affected by the dancer – by exquisite precision, timing, eloquent physicality, surprise and ingenuity in ways that I cannot get from

sport or athletics. What is it that enables me to connect with the dance and the dancer, but not with the game or the sportsman?

Understanding this connection better has potential implications for the training of dancers, for offering choreographers more informed choices and for developing approaches to promotion that are more focused on the audience experience. Audiences can be given permission to value their individual experiences and worry less about 'translating' the meaning. The National Campaign for the Arts 2006 Dance Manifesto talks about 'a great appetite for the kind of enrichment that dance provides – watching dance we feel a connection with the bodies on stage that goes beyond anything that can be expressed in words.' The knowledge that neuroscience possesses, and might yet discover, may help us begin to understand that connection.

Session 1: Simulation and Empathy

***Vittorio Gallese**, Professor of Human Physiology, University of Parma*

Wayne MacGregor**, Choreographer and Artistic Director of Random Dance, in dialogue with **Scott deLahunta

This session addressed the following questions: Can watching people's movements give us an insight into their minds? How far can an audience feel what a performer expresses physically? The first speaker, Vittorio Gallese, described a specific circuit within the motor areas of the brain that may allow us to simulate and empathise with each other. This is followed by an interview with the choreographer Wayne MacGregor, who has undertaken extensive research with neuroscientists at the Department of Experimental Psychology, University of Cambridge, where he developed his highly praised dance piece Ataxia, *and with heart-imaging specialists Dr Philip Kilner and Dr Sonya Babu-Narayan, with whom he created* Amu *('of the heart').*

Professor Vittorio Gallese

We possess mechanisms for seeing, transmitting and analysing what we see (the visual system), but a similar and unconscious process is going on at deeper level, in the motor system. This is a sympathetic nervous system, which causes the same neurons to fire in the observer's brain as in the observed's. Further, it appears to affect the same muscle groups in the observer as in the observed. In other words, not only do our brains perceive and learn, but so does our 'brain-body'.

We can isolate and research movement and find this brain correlate response for a wide ranges of actions. Mirror neurons firing in our brains allow us to distinguish and mimic generalised movement (in particular of the human form), specific action (a raised hand or foot) and even emotion, through facial expression. For example, when I see disgust in your face, the same area lights up in my brain as when I directly experience disgust, for example from a disgusting odour. When I see you touching another object – for instance, caressing the back of a hand with a feather – the same area for 'hand' lights up in my brain. When you raise a leg in the air, then that same area lights up in my brain. But there is more. Astonishing research has shown that the related muscle groups appear to be exercised too. With enough observation, the same muscle groups in the observer can be shown to have increased in mass! Perhaps we can get fit by watching.

The implications for dance are immediate and interesting. If mirror neurons lie at the heart of how we mimic and learn, then perhaps dancers could train a little less and look a little more. The dance world might welcome less stress on physical repetition and exercise, with the associated risk of injury, and become more interested in the effect of training through mental exercise and observation.

The research to date has been done on macaque monkeys. What research can we do to discover more about the mechanism in humans? In particular, can we isolate and discover

more about its effect in dance? Such work has yet to be done, but new research into the motor resonance response with actors may offer interesting comparisons.

Scientists are asking whether, at a neural level, we differentiate and respond differently to real and acted emotions, and to different orders of sound. Preliminary work shows that we respond more strongly to what we see than to what we hear, that we are better tuned to capture emotional expression than non-emotional expression, and that we can tell the difference between real (felt) emotion and acted emotion. In other words, we are good at spotting a lie.

We don't just see with our eyes but also with our 'brain-body'. At a neural level we mimic and learn movement and emotions and this is a necessary function of empathy. This modelling process is providing a scientific account of social cognition. Given its profoundly embodied nature, the implications of mirror neuron research for dance are rich.

Wayne McGregor *in dialogue with* ***Scott deLahunta***

Augmenting Choreography: Using insights from cognitive science[1]

Scott: The process of making both AtaXia *and* Amu *brought you into close working relationship with scientists.*[2] *Can you say something about this working relationship, this collaboration, in general, e.g. how it started, what sustained it? What were some of your discoveries?*

Wayne: All collaborations, whether they function between artists and other artists or between artists and scientists, are demanding. Their success is based not so much on the nature of each individual's specialism or level of expertise but on an ability to communicate well, to share ideas and to listen. This openness of approach and willingness to think outside of the box is vital to true collaborative endeavour where all parties are taken on a journey of mutual exploration. The science/dance collaborations that have been the most productive for me have been those that tread this path of investigation in a dynamic, fluid and ever-evolving form. The alchemy of collaboration throws up new challenges for everyone. It is how you deal with these challenges that sets the tone for fruitful exchange. I am beginning to understand from my investigation with cognitive psychologist Phil Barnard, for example, that what I articulate to be important in my creative process is always done in retrospect, and is in fact a memory of the process. It's a form of theatre in its own right, a construct. We have all acquired formulas to articulate our processes, necessary for funding applications, post-performance discussions etc., that are not accurate records, traces of the events that take place. This is a fascinating revelation and pushes one to genuinely reflect on one's process, utilising a completely different intellectual framework. These encounters have the potential to change thinking and bring us to an altered state; this is what provides the biggest catalyst for creation.

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[1] Excerpt from 'Augmenting Choreography: Using insights from cognitive science', Scott deLahunta, Phil Barnard and Wayne McGregor, in *Choreography in Contexts: Critical perspectives on choreographic practice*, ed. Jo Butterworth and Liesbeth Wildschut (Andover, New Jersey, J. Michael Ryan, forthcoming 2007).

[2] For information about *Ataxia* and the research with cognitive scientists see http://www.choreocog.net; for information about *Amu* and the research with heart specialists see http://www.oftheheart.org (date accessed 28.11.06).

Scott: Could you say something about how scientific processes (experiment/data collection) and science outcomes (descriptions/explanations) informed your creative process for both works. What information did you take back into the studio to make the dance/and how did you use it?

Wayne: The scientific 'experiments' Random undertook during the *AtaXia* process fed directly back into the dance-making to generate a new physical language. It's easy to see how and why this was possible. There was a very clear relationship between the aspiration of the research project (choreography and cognition) and my interest in undermining the relationship between the body and the brain and quite literally making the behaviour of the body dysfunctional. Experiments were facilitated to disrupt the body's ability to co-ordinate its movements, and these scientific choreographic interventions, or perturbations, actually made extremely able-bodied, virtuosic dancers unable to stand up, let alone balance. Through a series of dual tasks, vision disorientation techniques, motion capture/motor-control experiments etc., there were very practical puzzles for the body and the brain to solve. The process of solving the puzzles, the time it took to see the body and brain attempt to come to terms with the difficulty, and the ensuing solutions, provided the most useful information to capitalise on in the studio. It was the journey of thinking through the unfamiliar that was a greater resource than the actual end results. Because ultimately the brain finds a solution, it maps a framework that facilitates the task – the brain learns fast.

Practical experimentation is only one of the valuable aspects of a collaborative process with science. As important are the conceptual frameworks, discussions, debate, explanation and dialogue that surround the practical events. This transfer of knowledge(s) permeates the process in many fundamental ways. Choreography is very much about making decisions, and decisions are shaped by immersing oneself in the content of the work. Total immersion in the subject of the work allows strategies for making to emerge. It inspires new choreographic form with possibilities drawn from science but applied in dance; and opens up totally new territories of language because the currencies of language we are exposing ourselves to are non-arts-based. This was very evident in the *Amu* process where Random Dance were exposed to biological, medical, mechanical and spiritual 'learning' sessions, which included having our hearts scanned, watching open-heart surgery, understanding flow and dynamics of the heart, meditation techniques etc. Each new session built a more dynamic, richer imagination for the heart and resonated very individually with each artist. From this process of immersion came improvisations and physical investigations that drew directly upon our collective experience of learning about the functions of the heart and our individual experiences of building an empathy with our own heart. That is, science making visible the unknown, art using that discovery and translating it into something equally meaningful, but in a very different language. Sensibilities converge...

Scott: Where would you say the evidence of these projects (these working relationships) shows up in both the choreography (the art) and the science? (For the choreography this should be partly answered by your response to question 2, but if you have other thoughts about its value for choreography/art you could add that here; and can you say something about what you think the scientists get out of the relationship?)

Wayne: I think what is vital in genuine collaboration between art and science is the notion that neither is in the service of the other. Science cannot be used merely to serve the artist; artists cannot merely provide data for the scientist. These may be outcomes or aspects of the collaboration, but they are not or should not be the point of departure. Therefore, in all of the collaborative processes with scientists that I have undertaken I have not prioritised the making of a new work. New work has resulted from these dynamic exchanges but new work has not been the focus. The focus has been a series of questions, propositions, ideas to be thrown between us, tested, examined and explored. Some questions lead to experiments, some remain in the world of the abstract and are no less important. Some of the scientists we have worked with have published journal articles and given papers on work we have undertaken because during the evolution of our interchange particular points of interest converge with their science. Again, these have emerged and have not been a condition of collaboration. The outcomes of the science/dance collaborations have been varied and remain alive. The questions for all of us live on.

Scott: You are about to embark on another period of research with scientists that will inform the creation of the new work ENTITY*. Would you describe this is an evolutionary step: in other words is this next phase a development out of the previous two dance/science projects (or maybe not)?*

Wayne: The intention to develop *ENTITY*, an autonomous choreographic agent, has been with me for some time. Both *AtaXia* and *Amu* have gone some way to provide a framework for this research in that *Ataxia* looked at the direct connection between the body and the brain and discovered what happened when this connection was interfered with. The whole project was driven from the perspective of the brain being the central organism that controls everything the body does and experiences. *Amu* looked at the biological functions of the body through the filter of the heart and attempted to explore a connection between the heart and brain, ultimately exposing the generation of emotion. Both of these projects have used kinaesthetic intelligence as a starting point for exploration. The human body, connected to itself and its environment, a complex, complicated, virtuosic, thinking, memory-laden entity provides an unrivalled window into human experience. And dance – the most complete amalgam of all of the technologies of the body and brain – is a rich subject for never-ending research.

With this physical thinking in mind, the aspiration of building a new form of body, this *ENTITY* that has embedded inside it kinaesthetic intelligence, has come to fruition. We do not want to build a body that replicates human physical behaviour. On the contrary we want to build a body that can do the unexpected; after all, it will not have the restrictions of a 'real' body. Its decision-making processes and learning, although based on human kinaesthetic intelligence, should surpass human capabilities with an embodied imagination of its own. *ENTITY* should be able to interact with us in the studio but provide us with encounters with the alien, the unfamiliar, an uncertain artistic future that destabilises our formulas of making and disrupts our aesthetic sensibilities. *ENTITY* generates challenge.

Session 2: What Makes Movements Art?

***Chris McManus**, Professor of Psychology, University College London*

***Siobhan Davies**, Choreographer and Artistic Director of Siobhan Davies Dance Company*

Why is dance an aesthetic process as well as a physical and/or social activity? Chris McManus considered the principles of aesthetic judgement and its basis in the brain, while Siobhan Davies investigated the link between body movements, audience experience and dance as an art form, illustrating her talk with examples drawn from her choreographic process performed by dancer Sarah Warsop.

Professor Chris McManus

Ruskin is said to have observed that: 'The labourer works with his hands; the craftsman works with his hands and his head; the artist works with his hands, his head and his heart.'

Reference to the heart implies a level of implicit knowledge or understanding which probably relates to emotion. If science is to understand fully the modes and function of our emotional response to art, we must first classify in order to compare them, and somehow do this without destroying the experience.

While the research of neuroscientists currently engaged in investigating how the brain sees, and the consequent implications for understanding aesthetics is of interest – Semir Zeki's investigations into observing objects in motion, Ramachandran and Hirstein's aesthetic 'Rules', John Solso's research into visualising art – I believe their work either tries to explain away art or explains nothing of art as it is actually experienced in the lived world. The Oxford philosopher John Hyman has commented that with regard to a scientific understanding of the aesthetic, neuroscience can only address specific problems, such as why certain colour combinations cause different emotional experiences. It cannot provide an answer to deeper questions about the holistic experience.

In his 1997 book *Psychological Responses to Art* Bjarne Sode Funch posited a primary classification system via:

1. Aesthetic pleasure – ascertained simply by asking 'what do we prefer, or like better?'
2. Art understanding – the pleasure we get from thinking.
3. Emotional appreciation – we can isolate, say, jealousy in our appreciation of *Othello.*
4. Catharsis – an instinctual response.
5. Aesthetic experience – a quasi-religious state producing insights which may have lifelong effects.

I am particularly interested in questions of preference or taste and of finding ways of exploring these through scientific methodologies. To understand preference, for instance, the nineteenth-century German experimental psychologist Gustav Fechner looked at

differently shaped squares and simply asked his subjects, which do you like better? Clear preferences for the more upright shapes emerged.

In my own experiments I have chosen to look at the late work of the Dutch painter Piet Mondrian (1872–1944), who spent years fine-tuning his now familiar arrangements of blocks of primary colours and grids of straight vertical and horizontal lines, in order to find the most satisfying compositional arrangements. In this experiment I made digital reconfigurations of Mondrian's images, often making them more symmetrical, and then asked people to choose whether they preferred the pseudo-Mondrians or the originals. Interestingly, a higher than average number of people than can be explained by chance chose the real thing over the fake. This might indicate the fact that some compositional forms are innately satisfying, or again that a refined and deliberate aesthetic composition can be recognised as such.

Without drawing definitive conclusions, I believe that such evidence pointed the way for more experiments into notions of preference and taste in shape, form, colour and composition. It might be more challenging to apply this to moving images and dance but it would be worth trying.

Siobhan Davies

'It is difficult to *see* dance, to watch someone who is doing and feeling movement in a body that is not yours. The entire body is common to both dancer and observers. There is no separate presence, like the paper in a drawing. The dancer, the choreographed movement, the thought and the feeling are all embodied in the work. And the observer, sitting watching, is made of the same elements. While the dancer and the observer share the experience of living in a body, the audience has come to the performance expecting to see the body as an expressive figure rather than to experience simulated movement. They bring with them their own individual history that can pre-define what they see. Can we separate what we *think* we see, informed by memory and learned response, from what we actually see? Can we elicit an aesthetic response to pure movement, stripped of the formal trappings and conventions of a particular style of dance?

Usually we see dance in theatres and therefore associate it with theatrical narrative form, literally a story without words, but this association can mislead. To make seeing dance more difficult, dancers have the ability to shift attention between different parts of the body, movement and work; they can shuffle the logic of human movement. A figurative gesture shifts into an abstract use of rhythm and space, a pedestrian move nudges up against something more rare and complex. This is where dance becomes less narrative or linear in form.

I believe that seeing movement at close quarters makes it less abstract, more local and easier to understand. My company performed *Bird Song* in the round so the audience experience included recognising that the dancer uses all three dimensions and that she has a past, present and future in all directions. It was a series of events, transitions and fragments and each member of the audience collected their own particular shuffle of images.

I had a strict physical training as a dancer, and at the beginning my body felt less articulate than my thoughts, the movement seemed to own me. When I began choreographing I made work as I had *felt* it when dancing. I believed that an audience would sense the material of my body as I did. Having danced, then watched as a choreographer, I came to understand that the quality, texture and rigour of the sensations of dancer and observer are completely different. Choreography has to have feeling and thought.

[Siobhan Davies demonstrated the following experiment in movement with a sequence performed by Sarah Warsop.]

In making *Plants and Ghosts* in 2002, I asked the dancers to find the first move, which I then explored as a single cell containing all the movement DNA for the work. The cell could divide and multiply, each multiplication bringing more moves sharing the same DNA as the first. Movements could develop into different structures, forms and functions. This was the 'thought engine' behind the choreography, and the audience gradually became aware of gathering complexity.

When I speak to non-dancing friends, they enjoy the fact that they have the same constituent parts to their bodies as the dancers, and that dancers have metaphorically 'evolved' their limbs and torsos. Dancers seem to have unusual connections within and beyond their bodies, an extravagant and disciplined use of time. The audience borrows the dancer's body in order to be taken beyond their own limitations. Do they align themselves to the beauty and physicality of the dancer, or see the forms and structures of the choreography?

Session 3: Foundations and Formalisms

Jonathan Cole, Professsor of Clinical Neurophysiology, University of Southampton

Christopher Bannerman, Professor of Dance, Programme Leader MA Choreography and Head of ResCen, the Centre for Research into Creation in the Performing Arts, University of Middlesex

Jonathan Cole and Christopher Bannerman addressed questions of understanding bodily movement from within, or intuitively, and of observing it from outside, analytically.

Professor Jonathan Cole

I work with people who congenitally or as a consequence of viral infection have little or no sense of proprioception, or felt body knowledge. Most of us take the 'feel' of our own bodies in space for granted, holding in mind the different parts of our bodies and how they relate to each other without thinking about it, including the parts that at any one time we can't see. Dancers, however, work consciously with their bodies. They feel from within but they also think about their bodies in a heightened and disciplined way, and as a result have highly effective body knowledge and motor skills.

My patients think about it too. If they didn't, they'd fall over, or fail to figure out how to sit up, or grasp a heavy object without tipping, or turn a corner without tilting. Without consciously analysing, deconstructing, rehearsing and relearning the simplest movement, mentally and then physically, some of them would not be able to move at all. Over time, but with continual and concerted effort, they learn enough moves to navigate in familiar environments. For instance, to sit up they must learn to employ muscle groups in the stomach; to reach out and grab something heavy, they must stand firm and make rapid calculations if they aren't to be surprised and toppled by the weight of what they pick up. Walking involves the conscious consideration of forward leg movement with a simultaneous navigation of the environment and a continual analysis of visual clues.

Analysing how the brain relearns these movements provides fascinating insight into how we design and control movement, and this might provide fertile ground for further insight into the nature of dance.

Some of the patients also have an impaired sense of touch and I have observed that there is a marked and measurable difference between touch (a light and insignificant stroke with a feather, for instance) and emotion, i.e., between a poorly felt sensation and the pleasure it can nevertheless give. The anticipation and experience of pleasure, which is greater than and out of proportion to touch, is called affective communication. It is clearly observed in 'grooming' behaviour amongst groups of animals and similarly in humans. Small gestures of touch can evoke pleasure and reciprocal movements, serving to calm and organise both individuals and groups. It may also help to explain in dance (and indeed in other forms of exercise) the correlation between exertion and satisfaction, of action and the pleasure felt afterwards.

We are visual animals, designed to recognise and read meaning from remarkable movement, whether safe or potentially threatening. Motor fluency may be outstandingly graceful and charming as with the gambolling of horses or lambs, the tumbling of a puppy or tottering of a small child. But we are equally alert to unexpected movements – inappropriate gestures, the clown's stumble or the tiger's spring. All movement has meaning for us, often linked to emotion. In the words of the great Russian neuropsychologist Alexander Luria, we have evolved to see all around us 'the kinetic melody' of existence.

Professor Christopher Bannerman

There is a paradoxical dilemma in any analysis of performance. If we think too much about what we experience, whether as practitioners or audience, we risk destroying it. Should we prioritise intuitive knowledge? Should we even talk about what we see?

What we know as 'intuition' is fundamental to inducing and enhancing creative states of mind and its power should be respected and protected – and trusted. Intuition is essentially non-verbal or pre-verbal, a balance of mind between what is known and yet to be understood, a pregnant pause. It is often elusive. Dancers will go to curious lengths to find a mental distraction when they are about to undertake a performance, whether in rehearsal or before an audience, in order to defocus the analytical mind and induce a non-verbal brain state ready to create or 'absorb' the new. We see it elsewhere, in the averted gaze, in the power of ambiguity, in the Madonna's *sfumato* smile.

Attempts to evaluate performance through rational and analytical means effectively kill the intuitive brain state, like the pin in the butterfly. Something is lost when dance movement is objectified, repeated or recorded. This is not to say that such processes are redundant or unnecessary; in essence they are attempts to keep alive the creative impetus and this is a challenge for the choreographer in particular – how to take an intuitively formed movement and give it meaning for an audience without losing something of its raw power. It is also an issue for the audience who often in retrospect feel they must respond to physical performance with verbal analysis. How far does this drive to find 'meaning' inhibit the making and viewing of good art? In a culture in which rational evaluation has primacy, it seems to be necessary to try to say what dance *means*, rather than simply talk about what it *is*? Chris McManus expressed the same concern when he asked whether science could illuminate art without explaining it away.

What we need is the means to understand and value the kind of creative non-verbal state which Siobhan Davies described, moments in time held suspended between the performance and the audience. Perhaps it is the audience which should learn to look with an averted gaze and after the event discuss not what a performance *means*, but what it *is*.

Session 4: Cultural Influence and Form

***Ruth Webb**, Lecturer in Classical History, Birkbeck, University of London*

***Patrick Haggard**, Professor of Cognitive Neuroscience, University College London*

Dance movements often seem to be over in a flash, though may require years of experience to execute. They may then remain in the memory and dance legend for years to come. How can the immediate, dynamic life of dance be captured and communicated and what can the process tell us about how dance 'works'? Ruth Webb focused on dance in a particular cultural setting – during late antiquity – which served to remind the audience how form and style in dance reflected the mores of its time. But she also pointed out that an underlying suspicion of the protean emotional posturing of performance still maintains today. Patrick Haggard presented his scientific research into changing styles in dance movement.

Ruth Webb

The term 'pan-to-mime' originally referred to the 'miming' of 'everything' – of all life. In Late Antiquity solo professional dancers were trained to conjure on stage an illusion of real life. The performer exhibited enormous metaphorical power, sometimes in a manner so convincing that by the sixth century AD, pantomime was suppressed by Christian authorities for its anarchic, demonic and threatening nature. Interestingly, a perception of public performance as dangerous may still persist today.

What gave these performances such power? Using masks, but no change of dress and a series of learned gestures and techniques, the narrative of the piece was communicated largely through movement and expression. That movement was highly athletic, full of whirls, stops, leaps and squats; it was 'sinewy and tense' and driven by strong, rhythmic music. Pantomime performers were trained through gymnastic techniques, often from three years of age. Physical techniques were encoded in the body early and narrative techniques were learned through *mimesis*. Their craft was learned entirely through copying actions – gesture first, then the attributes of character. (Method acting and performance training still employ these techniques and similar protocols are also practised in South-East Asian dance.)

For the Christians authorities this was all too much. There prevailed an idea that constant imitation could lead to actual transformation and that even gesture could change mood. In a pre-Freudian ancient world, attributes of personality were considered to be absorbed from experience, the self a construct of the exterior. The donning of masks and the ability to take on the personae of different characters, displaying rapidly shifting emotional states, was to seen to align the performer with the devil. Thus, dance was a dangerous act and the ancient world was alive to its power.

Audiences then and now seek to be moved and transported by what they see. However, an ancient audience would have been steeped in the technique and meaning of pantomime. By contrast, modern Western dance, at least, must often communicate across a vacuum with an audience less knowledgeable about the coded meanings and power of performance and much less prepared to respond.

In many cultures dance has traditionally been used to invoke heightened emotional responses, even a trance effect, which have been found to be the consequence of raised levels of serontonin, endorphins and opiates in the brain. A desire for heightened states of awareness has clearly not diminished in modern culture. Nor has the measurable sensation of pleasure when we experience the unexpected. When the ancient performer broke with the 'schemata' of the dance pattern, or when the modern dancer makes a surprising move, there may be a distinct pleasure, which is an event in the brain and the audience's reward.

Professor Patrick Haggard

The human brain has evolved special systems for representing human posture and movement, for obvious survival reasons. We need to recognise our loved ones at a distance before we aim an arrow at their chest, and lions in the undergrowth before they eat us. Chris McManus demonstrated that we prefer upright postures to oblique or tilted lines. Our brains like us upright, in familiar postures, and are quite easily deceived by unfamiliar orientation.

In a famous experiment carried out in the 1980s, scientists inverted the eyes and mouth in a photograph of Mrs Thatcher and set it side by side with the correct version. Although in the manipulated version the eyes and mouth are upside down, few people noticed the difference. It isn't until the manipulated image itself is turned upside down that the brain recognises the inverted features and we know we've been tricked.

How, then, does the brain make sense of the body postures and body movements that we see in dance? Are dance postures understood by our brains as whole configurations, or as a collection of parts (hands, feet, etc.).

It turns out that different areas of the brain see the body in different ways. The research team at UCL has used Trans Magnetic Stimulation (TMS) to interfere with the activity in the premotor cortex or in the extrastriate body area, located in the motor and visual regions of the brain respectively. When the experimenters disrupted activity in the premotor cortex, participants' recognition of dance postures was altered. They failed to see the entire configuration of the body and recognised postures based only on local details.

The next question is: do these ways of seeing influence the subjective response to what one sees? This is, in part, an aesthetic question. In one study, participants first viewed dance moves while their brain activity was recorded with Functional Magnetic Resonance Imaging (fMRI). In a later experiment they viewed the moves again and judged how much they *liked* each one. There was a clear preference for highly athletic movements such as jumping and rapid steps, also for abrupt changes and surprising moves. This preference correlated with increased activity in the right premotor cortex, one of the classic 'mirror neuron' areas.

Current research is repeating the same studies with expert dancers. Dancers have special ways of seeing which may reflect the processing of the brain's visual and motor systems. Work in progress will use fMRI to investigate these systems in both the expert and the naive observer and will assess how they contribute to aesthetic experience.

Does dance develop in response to aesthetic preference, or vice versa? Has the 'line' in ballet altered over time and, if so, how and what might we infer from it? The Royal Opera House archives hold visual recordings of the *Rose Adagio* from 1962 to 2003. It has therefore been possible to select and compare a single movement in order to trace shifts in that ballet 'line' over 41 years. Over this period, the leg has pointed higher – a 47 degree angle in 1962 had become 180 degrees in 2003, i.e. to a straight vertical. Similar trends are present in a variety of moves and moments. Why may this be?

Changes in dancer fitness might be involved, but there may be an aesthetic evolution at work also. These images were shown in pairs to a group of naive observers and again they were asked which they preferred. They were shown not the original photographs but what are called 'boundary objects'. As in a joining-the-dots diagram, a line is drawn between the end points of the dancers' bodies – between head, hands, feet – which describes the outer shape of the movement and depersonalises the image. Naive observers time and again preferred the higher leg elevation and the same was true for all postures.

While this is partly cultural, it seems clear that aesthetic preference can be recorded and analysed scientifically.

Other Research in Dance Science

*This session involved **Emma Redding,** Director of MSc Dance Science, and **Shantel Ehrenberg,** Dance Science Researcher, both at Laban, London, and **John Gruzelier**, Neuropsychologist, Goldsmiths, University of London*

Emma Redding and Shantal Ehrenberg

Sports and dance science have much in common but dance-specific research, couched in the movements, language and cultural references of the dance world, is critical. In 2001, the world's first Dance Science degree programme was launched at a specialist dance college, Laban.

Some key questions for dance science are:

1. How can we enhance dance training and performance?
2. How can we validate dance as a special or different physiological and psychological activity?
3. How do high performing artists see themselves and what are the implications for dance learning and choreography?

Laban is currently undertaking a large dancer screening programme, studying the effect of dance on the body, mind, health and well-being of the dancer. Of particular interest is whether and how dancers make their own internal judgement of progress. Can this be enhanced through technique? Can dancers learn to rely less heavily on the external judgement of the teacher or director, with the concomitant labelling of progress as 'good/bad', 'pass/fail'? How far can science enrich our understanding of the mental processes involved in dance learning? What might the implications of such a shift in the pupil/teacher relationship be? Questions about how dancers develop self-knowledge, how much they rely on visual systems and/or proprioception, and how they know when they are at peak performance all have implications for dance learning.

John Gruzelier

The use of biofeedback from electroencephalography (EEG) data has been around since the 1960s and is currently being used in some areas of music training to help musicians improve their technique and performance. Through the measurement of electrical wave functions in the brain there appear to be two brain states of significance in creative performance: one fast, the other slow. The fast or alpha wave state predominates when practitioners are engaged in activities requiring tension, memory, and conscious awareness and analysis. The slower, or theta, wave state prevails during creative learning. If students are made aware of their brain states, through watching digital monitors, they learn to influence their brain wave patterns through making a conscious effort to slow down. Experiments with senior music students to help them cultivate the slower theta brain state have shown a

marked degree of improvement in musicianship, sometimes equivalent to as much as two levels of a music degree.

Further research with Heart Rate Variability training, which develops a coherence between breathing and heart rate, shows that when in that ‘coherent’ state, there is also an increased learning potential. At present these two research practices are separate, but bringing them together could further increase learning potential.

To date, slow-wave or theta training has been primarily applied to children with Attention Deficit Hyperactivity Disorder (ADHD), as it is proven to calm and allay social fears as well as to improve learning. Can this work be applied to dance and improve performance as dramatically? Would it work with non-professionals and junior students, perhaps less adjusted to highly tuned learning modes? Ballet teachers are already impressed by the implications that the brain might be harnessed to do more work and the body given a bit of a break. It is becoming evident that brain-wave and heart-rate training might be harnessed to improve technical and artistic execution.

Conclusion – The Future

This rich and rare day marked the beginning of a new conversation between dance and science. Participants met in a spirit of curiosity, open-mindedness and harmony. As a result, it was a day full of humour, insight and connection. It was illuminating to see scientists scribbling away as choreographers and dance directors spoke. It was inspiring to see moments of recognition, or a particularly satisfying thought association, as the dance community absorbed the science and its implications. It was a genuine two-way dialogue between an art form in the process of defining itself and a new science eager to better understand the complex nature of being human.

The following propositions are offered as possible ways forward, to promote the creating, sharing and transfer of knowledge across the nascent dance and neuroscience community.

Dance science could mature as a distinctive discipline by embracing the observer and the performer. Placing the physicality and psychology of optimum performance in their cognitive, cultural, and aesthetic context would be informative and would build the dance-science community. Consideration of the process of the exchange between observer and performer, of what happens to the observer, would move dance science into a realm that is evidently distinct from sport and which has a potential impact across the wider interests of dance and neuroscience. It might lead to the formation of an academic society for dance science to promote further understanding through regular papers and conferences.

Science can recognise that dance is still relatively uncharted territory compared with the visual arts or music, areas in which there has been a significant amount of research. Dancers have an exceptional understanding of the way their bodies function and move but their performance also links to the emotional and communication systems in the brain. Such sophistication might be of genuine use to scientists.

Making new dance A greater understanding of the neuroscience underlying dance should not only affect the training of dancers but also influence choreographers to work differently, and even inspire the creation of new dance works which address these ideas, many of which have profound implications for the way we think of the human condition. Wayne MacGregor has already made startling new dance pieces following his research with scientists.

Dance promotion would gain new tools and perspectives by recognising that observers experience mental simulation and empathy when watching dance. This experience undermines the perception that dance is only for a few informed people, and positions the act of watching dance as a fundamental form of human interaction, universally available. It gives everyone permission to experience the language of dance without the need to be able to translate it.

Education can learn from the essential process of ‘you move, I watch’, to reclaim the value and effectiveness of ‘copying’ as a means towards embodied understanding. Dance could not have evolved as an art form without the human capacity for embodied understanding

and empathy. There are implications for the process of learning, pedagogical approaches, and theatre, particularly for young people.

The UK Branch of the Calouste Gulbenkian Foundation will encourage further developments through disseminating this report as widely as possible, prompting public debate and media coverage and continuing to work with leading artists and scientists at the cutting edge of practice and discovery. We look forward to hearing more about developments, and invite anyone who has further knowledge or questions, or who may have been inspired by reading this report to send a brief summary to sian.ede@gulbenkian.org.uk.
